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G1S
Selected US specifications from IPC sub-classes G01F G01N

(54) Analysis of fluid gas content

(57) Portable apparatus for analysis of a sample of a liquid containing dissolved gas (eg obtained from an oil well) comprises a reservoir (4) for the sample (5) and a thermostatic chamber (2) containing a gas pressure reduction cylinder (20, 21, 22), the central section (21) of which is of transparent sapphire and in which a piston (23) travels in air tight manner. A hand pump (10) is used to introduce auxiliary fluid (7) beneath a free piston (6) in reservoir (4) thus expelling a measured sample of the liquid via a valve (36) into the lower part of the cylinder. Piston (24) is raised under control of a pressure sensor (28); gas (19) evolved from the liquid passes along a pipe (17) from the upper part of the cylinder and collects in a gas collecting vessel (15) above a flexible membrane (16). Auxiliary fluid displaced from vessel (15) is collected in vessel (30) and may be weighed to determine the volume of evolved gas. The volume of gas beneath the piston in transparent section (21) may also be determined by optical level detecting means (25,26). Gas pressure above membrane (15) may be utilised in order to introduce further measured samples into cylinder (20,21,22) from reservoir (4).

Fig. 2

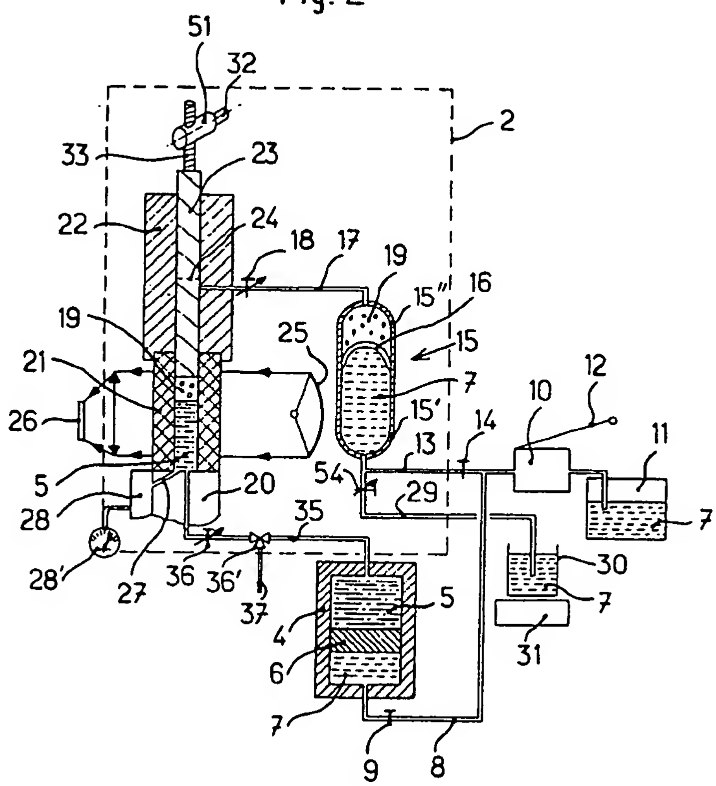

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Fig. 1

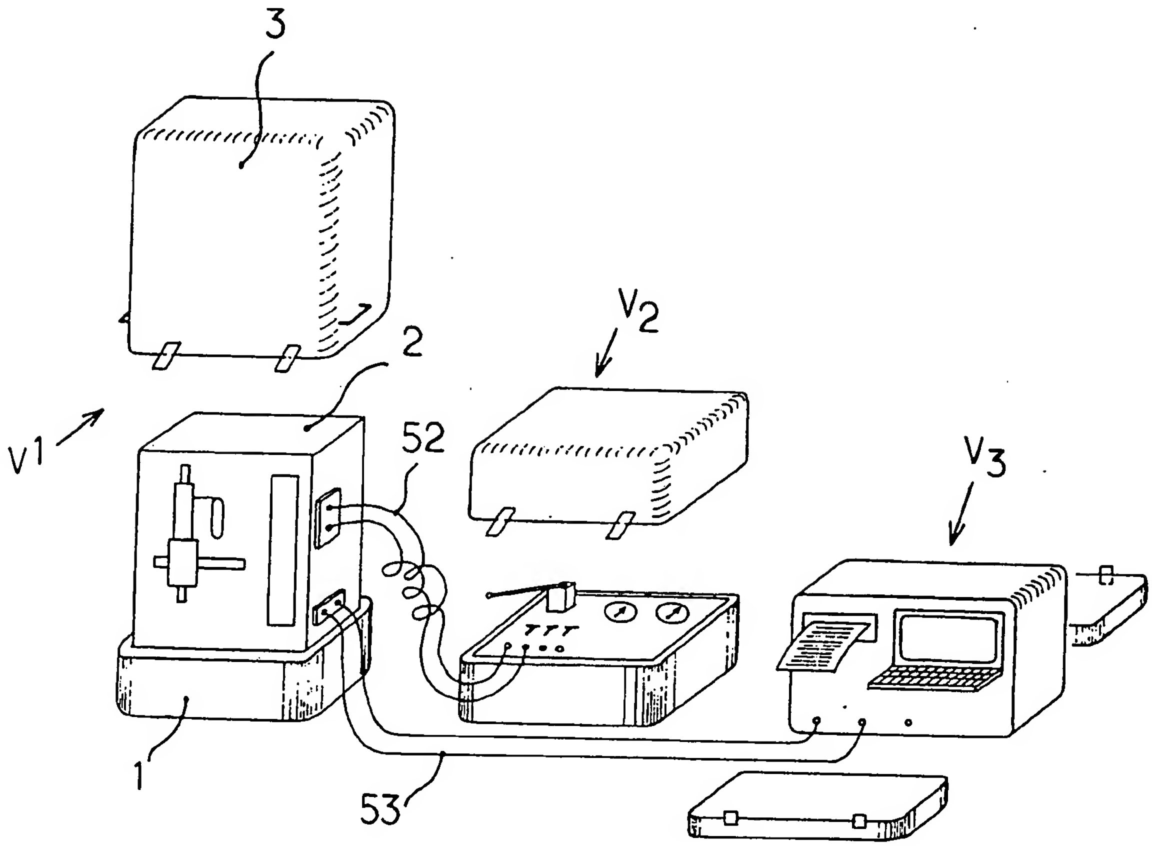

Fig. 2

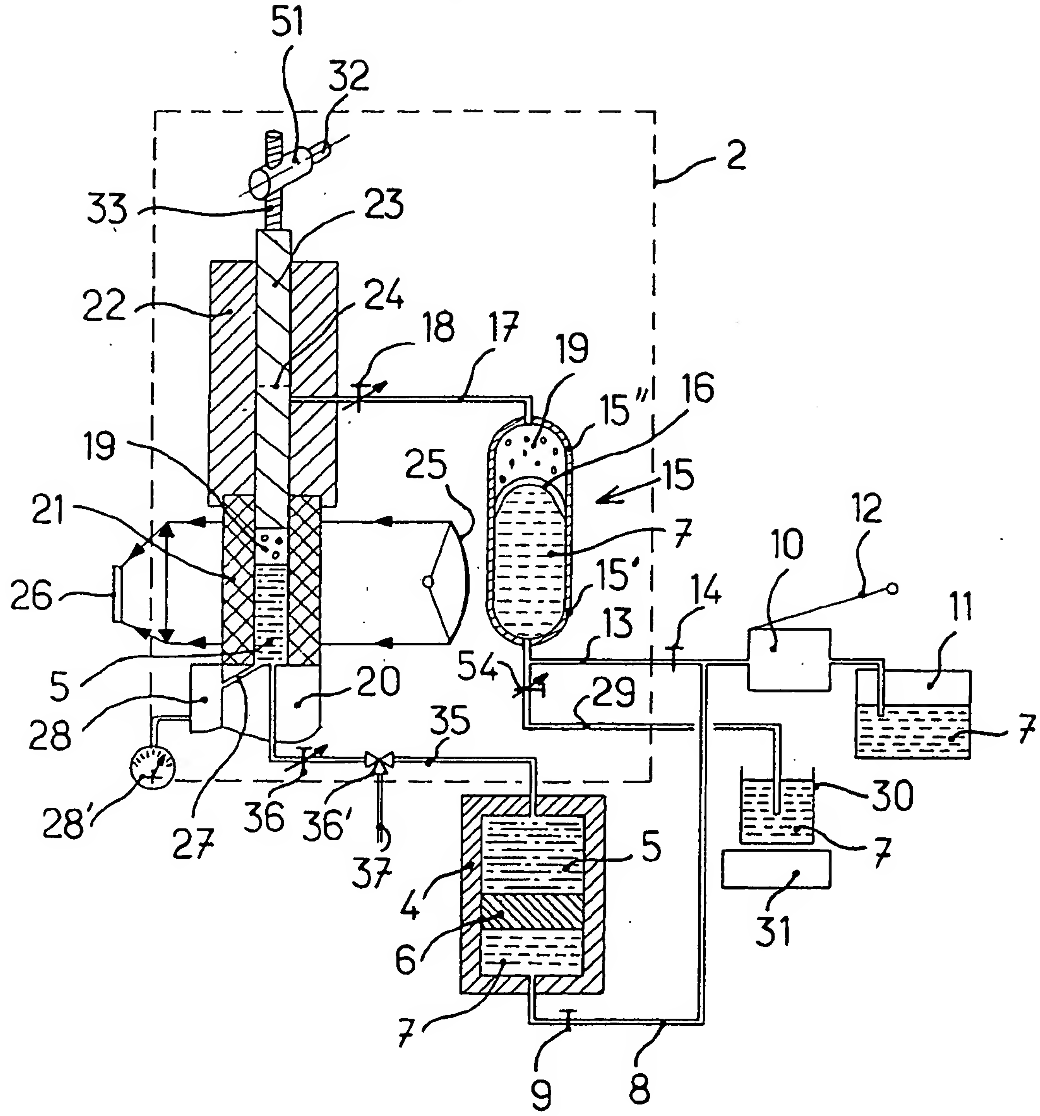
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Fig. 3

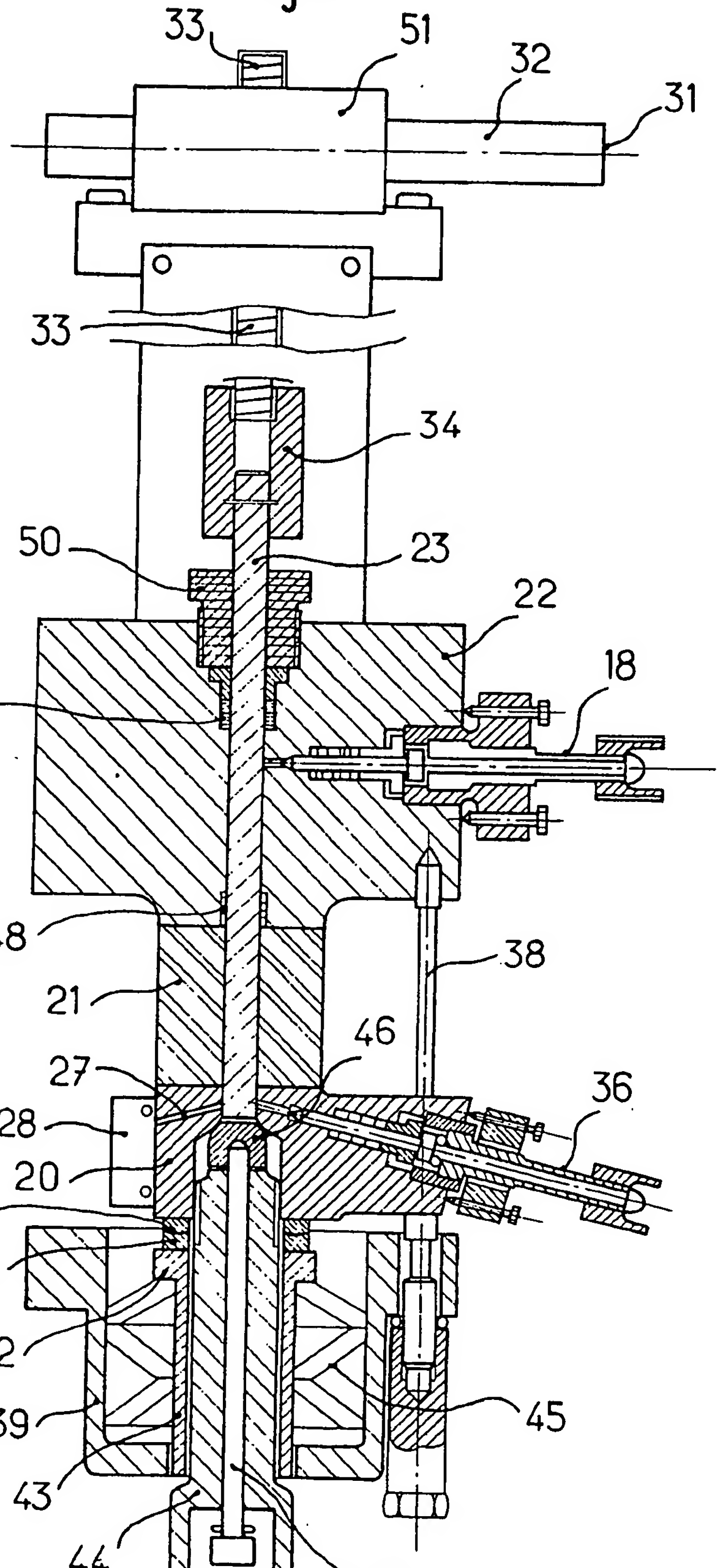
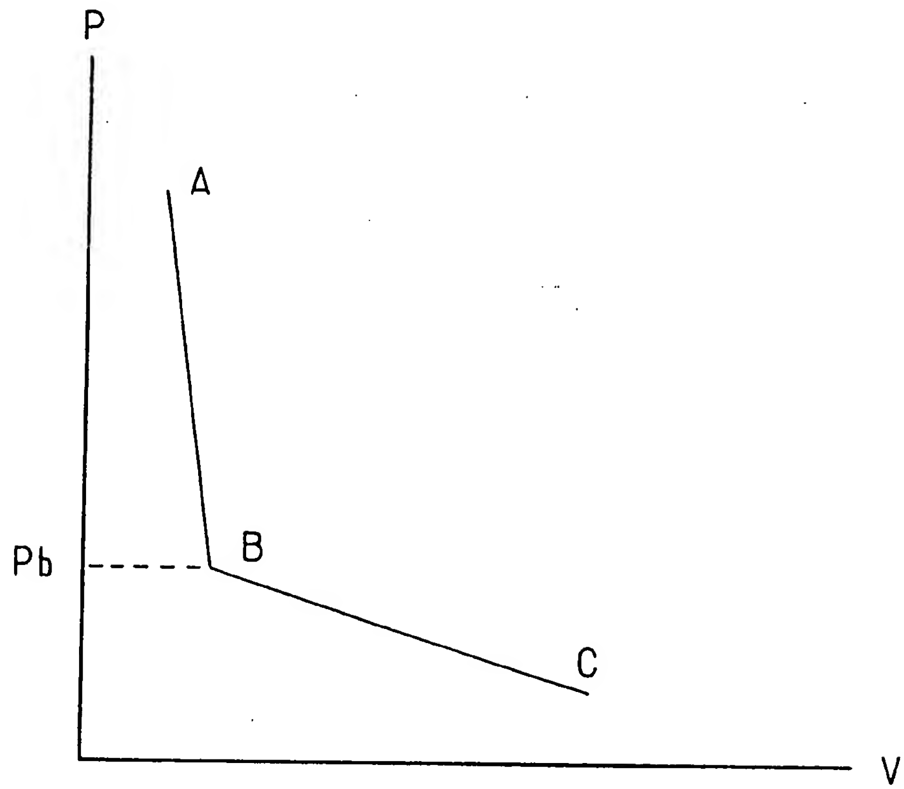


Fig. 4



SPECIFICATION

Automatic device for analysis of a fluid

The present invention relates to a portable automatic device for the thermodynamic analysis of fluids obtained from underground.

As is known, it is usual, in order to determine the parameters for exploitation of an oil well, to remove from such a well a sample of a fluid to be analysed, for example a sample of oil or of geothermal water, and to subject this to a thermodynamic analysis known as "PVT" intended to determine the evolution and variations in characteristics of this fluid, whilst varying its pressure, in particular by simulating the pressure reduction which results when such a fluid passes progressively from the temperature and pressure in the reservoir to atmospheric pressure and the normal temperature during the production flow of the well.

Hence it is necessary to know in particular at which pressure the fluid produced becomes two phase, i.e. separates into a liquid containing a dissolved gas and into a free gas (the bubble point), to determine the gas/oil ratio (GOR), i.e. the quantity of gas which is produced per unit of volume of liquid, and to find out the coefficient of compressibility and the density of the liquid under reservoir conditions.

In fact, the various parameters mentioned above are indispensable for planning and assessing the size of a specified type of equipment for the well to be exploited and for selecting in particular, with a view to its production, the necessary surface installations, such as gas-oil-water separator, storage tanks, pumps, etc.

To obtain the sample to be measured, one either removes it from the bottom of a well under the temperature and pressure conditions of the reservoir, using appropriate known methods, and transfers it to a metallic storage bottle under pressure, or it is obtained by removing a sample of liquid and gas in a separator and recombining these at the surface, in appropriate proportions, returning them to the pressure of the reservoir.

Classical PVT laboratories are equipped with pressurised cells which may be adjusted by injecting mercury by means of a specially designed pump and which are capable of containing some tens to some hundreds of cubic centimetres of sample; these are heavy, complex installations, difficult to transport and requiring moreover delicate handling of the mercury.

The invention eliminates the disadvantages of the installations mentioned above and provides a portable device, relatively light, automated by known techniques and comprising neither mercury nor a complex volumetric pump, the said device being able to commence operation directly in situ as soon as the sample to be analysed has been removed. The main aim of the device is to ensure an immediate, relatively simplified analysis of the sample, to check that this latter is of good quality and representative of the reservoir and that therefore it may be kept for subsequent, more detailed analysis and, in addition, to provide immediately within a few hours, the first approximate values of the above-mentioned parameters, i.e. bubble point, compressibility, density and "GOR".

The device in accordance with the invention is essentially characterised by the fact that it is contained, together with the electronic monitoring and control devices which are connected to it, in various transport cases equipped with the necessary hydraulic and electronic linking components.

According to an important characteristic of the invention, the device to which it relates comprises in combination a reservoir containing the sample to be analysed, a pressure reduction unit linked to the said reservoir and consisting of a cylinder comprising a transparent section making it possible to read, with the aid of an optic-electronic device, the level of the sample sucked into the above-mentioned cylinder by means of a mobile piston moving progressively, the remainder of the liquid to be analysed being pulsed into the storage reservoir by a piston, which is subject to the action of an auxiliary fluid contained in the lower part of a gasometer divided into two chambers by a flexible membrane above which accumulates the gas produced by the sample when the bubble point of this latter has been reached in the cylinder of the pressure reduction unit.

In order to be able to supply auxiliary fluid on the one hand to the reservoir containing also the sample to be analysed, and on the other hand to the reservoir receiving the gas given off by the sample, a supply reservoir is provided from which the auxiliary fluid, for example silicone oil, is sucked by means of a hand pump, making it possible, with the aid of a three-way valve provided at its outlet, to adjust as required the level of auxiliary liquid, on the one hand in the gasometer connected to the gas reduction unit and on the other hand in the reservoir containing also the sample to be analysed.

According to another characteristic of the invention, to enable the pressure of the auxiliary liquid in the gasometer to be regulated, an automatic-control throttle valve is provided, mounted on a pipe for evacuation of the auxiliary fluid which leads to a reservoir resting on scales, the purpose of which is to determine the weight of the auxiliary fluid expelled by the gas given off by the sample during pressure reduction and which has entered the gasometer.

In a preferred embodiment of the invention,

the throttle valve regulating the volume of auxiliary fluid in the gasometer is triggered by the signal given off by a pressure sensor which, connected by a pipe to the volume of liquid to be analysed contained in the pressure reduction cylinder, also controls the lifting mechanism of the piston travelling in the pressure reduction cylinder.

Other characteristics and advantages of the invention are apparent from the following description with reference to the appended drawings which represent, in diagrammatic form and simply by way of example, a non-limitative method of construction of the automatic device of the invention for the thermodynamic analysis of an oil sample.

In these drawings:

Fig. 1 is a diagrammatic view in perspective of the device, showing the division into three portable cases of the components of which it is composed;

Fig. 2 is an elevational view on a larger scale, partly in section, of the device, the electronic control and recording devices illustrated on the right-hand part of Fig. 1 not being shown;

Fig. 3 is a large-scale elevational view partly in section, of the main body of the pressure-reduction unit of the device; and

Fig. 4 is a pressure-volume graph for finding the bubble point of a sample.

As can be seen from Fig. 1 of the drawings, all the units making up the device are housed, in the example represented, in three cases designated generally by the references V_1 V_2, V_3, case V_1 being capable of forming, during transport, an hermetically sealed chamber, and being intended to receive the components of the device which are contained in the box shown by a dotted line in Fig. 2, as well as the reservoir for storing the sample of liquid petroleum to be analysed; As far as case V_2 is concerned, this contains the hand pump, the auxiliary fluid reservoir and the reservoir for evacuation of the auxiliary fluid expelled from the gasometer, as well as the scales for weighing the same and for thus determining the volume of gas which has entered the gasometer.

As for case V_3, this comprises, in known fashion and for which no specific novelty claim is made, all the automatic monitoring and control electronics making it possible to regulate the temperature, to program the pressure, to obtain all results in the form of curves/tables, and to control automatically the operation of the system, these various devices not being described in detail in this specification.

Case V_1 comprises a base 1 enclosing a thermostatic chamber 2 containing the components shown in the box, also designated by the same reference in Figure 2 of the appended dra[illegible]

As Shown in Fig. 2 of the drawings, which illustrates the entire device in diagrammatic form, with the exception of the electronic control and monitoring devices shown on the right-hand part of Fig. 1, the device for thermodynamic analysis in accordance with the invention comprises a reservoir 4 in which the fluid 5 to be analysed is contained above a floating piston 6 supported by the pressure of an auxiliary fluid 7 supplied via a pipe 8 controlled by a valve 9 and brought in by a hand pump 10 taking this auxiliary fluid from a storage receptacle 11. The hand pump 10, operated with the aid of the lever 12, is also used to send via pipe 13 controlled by valve 14, auxiliary fluid into the lower section 15′ of a gasometer 15 which, in the form of construction represented, is in the shape of a bottle and also comprises an upper chamber 15″ separated from the auxiliary liquid 7 by a flexible membrane 16, the said upper chamber 15″ receiving, via pipe 17 controlled by a valve 18, the gas 19 given off by the oil sample 5 to be analysed, which has been previously introduced into the gas reduction cylinder, the latter having three sections 20, 21, and 22 which will be described later, and which contains a mobile piston 23 capable of being progressively and steadily lifted into the above-mentioned cylinder until it reaches the level designated by the reference 24, thus enabling the sample, when bubble point is attained, to give off the gas which it contains and to send it into the chamber 15″ of the gasometer 15 via the pipe 17 controlled by the valve 18. The central section 21 of the pressure reduction cylinder is preferably transparent and is made most preferably of a sapphire, and its mounting is described in more detail below, with regard to Fig. 3.

This transparent sapphire is used on the one hand to enable the detection of the liquid-gas interface of the analysed sample 5, an interface which is optically projected with the aid of a light source placed in the centre of a parabolic mirror 25 providing a collimated beam which irradiates one of a number of photo-diodes 26 sending a signal to the level-measuring device forming part of the electronic control and monitoring system which is not particularly illustrated. The lower section 20 of the cylinder comprises a pipe 27 leading from the pressure reduction chamber of the sample 5 to a pressure sensor 28 provided with a measuring dial 28′ and triggering the lifting mechanism of the piston 23 in the pressure reduction cylinder. The upper section 22 of the cylinder is of sufficient length to enable the piston 23, when rising into the cylinder 21, 22, to pass beyond the level 24 situated above the outlet of the pipe 17 through which the gases 19 given off by the sample 5 pass into the upper section 15″ of

its lower section 15′, a pipe 29 for evacuating the auxiliary fluid 7 into an evacuation reservoir 30 resting on scales 31 which are used, by measuring the weight of the auxiliary liquid 7 evacuated into the reservoir 20, to determine the volume of gas 19 produced by the analysed sample 5.

Fig. 3 of the drawings shows in detail the construction of the parts 20, 21 and 22 of the cylinder. In this figure, the reference 31 refers to the coupling point of a reducer 32 with the driven shaft of a motor not shown, the said reducer serving to operate an endless screw 33 moving upwards, via a coupling 34, the piston 23 which sucks up the sample of fluid 5 to be analysed.

The pressure reduction chamber which is provided in the cylinder to receive the sample 5, is connected, at the lower part of the sapphire 21, via a pipe 35, to the upper part of the reservoir 4 containing the remainder of the fluid 5 required for several successive analyses each of which requires, preferably, a cubic centimetre of fluid to be analysed. This pipe 35 is controlled by a needle gate 36 and comprises also a three-way valve 36′ which is used to introduce, via pipe 37, the sample 5 of fluid into the reservoir 4.

From the point of view of construction, the sapphire 21 is wedged between the upper block 22 and the lower block 20 which are held together by four braces 38, only one of which is shown on the right-hand side of the drawing. These braces 38 secure a part 39 shaped like an inverted bell which itself secures the block 20 with the aid of a double washer 40, the two components of which are separated by a spherical contact surface 41. This washer is pressed against the component 20 by the flange 42 of an intermediary sleeve 43 housed in the bell 39 around a lower closing component 44, the said flange 42 serving to support a set of Belleville washers 45 housed in the bell 39. The lower closing component 44 consists of a threaded sleeve which is screwed into the unit 20, securing a nut 46, which may be extracted by a screw 47 extending through the closing component 44.

As far as the piston 23, which is shown in its lowest position in Fig 3, is concerned, its air-tightness is ensured by joints 48 and by a packing-box 49 pressed around the flange of the piston 23 by an adapter sleeve 50.

The endless screw 33, activated into vertical movement by a reducer 51 with balls eliminating play, pulls, via the coupling 34, the piston 23 upwards, moving it away from the nut 46 and thus enabling admission of the fluid 5 into the pressure reduction chamber provided in the sapphire 21.

Most of the components shown, as well as the piston 23, are made of stainless steel resistant to sulphurous corrosion. As far as the valves 18 and 26 are concerned, their needles are remote-controlled with the aid of motors equipped with angular encoders which are not illustrated.

The automatic control of these valves and of the movements of the piston, is effected by known electronic devices which are housed in case V_3 shown in Fig. 1 and which trigger the movement of the piston according to a timed program or to a programming of the pressure constantly measured by the pressure sensor 28.

The operation of the device is as follows: After removing the cover of cases V_1, V_2 V_3 suitably placed in situ, the operator ensures hydraulic or electronic linking of the various measuring components with the aid of hydraulic connections 52 linking cases V_1 and V_2 and electronic connections 53 linking cases V_1 and V_3 After introducing via pipe 37 and the three-way valve 36′ some fluid to be analysed into the pipe 35 leading to the reservoir 4, he ensures connection of the said reservoir to the pipe 35 by again adjusting the three-way valve 36′. By hand-pumping, with the aid of the lever 12 of the pump 10, some auxiliary fluid 7 into the reservoir 11, the valve 14 also being open, he sends auxiliary fluid 7 simultaneously under the floating piston 6 in the reservoir 4 and into the lower part of the gasometer 15, under the membrane 16 which is then pressed against the wall of the said gasometer. These preparatory steps having been completed, and a valve 54 controlling the pipe 29 being again open and the valve 14 being closed, the operator then ensures the return of the piston 23 into the cylinder and the sucking into the chamber of the sapphire 21 of a measured quantity of sample, for example one cubic centimetre. The movement of the piston 23 is also controlled by the pressure sensor 28 which, as a function of the pressure present in the chamber of the sapphire 21, sets off the triggering electronics of the motor-driven reducer 51 coupled to the endless screw 33, ensuring the upward motion of the piston by means of the coupling 34.

The required sample 5 having been placed in the sapphire 21 and the valve 36 being then closed, the entire pressure reduction system and the gasometer 15 is located in the thermally insulated and thermostatic chamber 2.

The operator then brings the whole to the constant temperature required, in principle that of the reservoir from which the sample 5 to be analysed was obtained; of course, during heating, the mechanism for lifting the piston 23 continues to be triggered automatically by the pressure measured by the pressure sensor 28 so that the pressure is constant and is in principle higher than that of the reservoir, so that an appropriate safety margin is maintained.

Once thermal stabilisation has been achieved, one may commence pressure reduc-

tion by proceeding, on the basis of a programming established in advance, to raise the piston 23 slowly and progressively at a constant speed. During this movement, the volume of the sample is determined by monitoring the exact position of the piston 23.

When the pressure attains bubble point, the sample 5 commences to degass and a pocket of gas 19 is formed between the sample 5 and the piston 23, as shown in Fig. 2.

As far as the bubble point is concerned, this is determined precisely, according to the known classical method, by drawing, as illustrated in Fig. 4 of the drawings, a PV diagram (pressures on the y-axis and volumes on the x-axis) which shows variations in pressure as a function of volume.

In Fig. 4, the line AB represents the pressure reduction of the single-phase fluid sample and the line BC the pressure reduction of the gas; at point B where the lines intersect one finds the bubble point Pb. By measuring the angle of the line AB, one can determine the compressibility coefficient of the single-phase mixture.

The pressure reduction is continued by raising the piston 23 until its base reaches the mark 24. The total distance travelled by the said piston between the nut 46 sealing the lower part 20 of the cylinder and the mark 24 is, in the case in question, 123 mm, the height of the sapphire 21 being 50 mm and the diameter of the piston 23 being 6.35 mm.

If the pressure is still too high when the piston 23 reaches its upper retracted position in the section 22 of the pressure reduction cylinder, pressure reduction is continued in such an event by opening the valve 18 and by sending the gas 19 into the upper section 15″ of the gasometer 15, the other section 15′ of which, separated from the upper section by a flexible membrane 16, is filled with auxiliary liquid 7 transmitting the pressure provided by the hand pump 10.

The pressure of the fluid 7 held in the lower section 15′ of the gasometer 15 is controlled by the automaticcontrol throttle valve 54 triggered, via the electronic control and programming device not illustrated, by the signal given off by the pressure sensor 28, so that the valve 18 being open, one can establish in the device any predetermined pressure desired and/or programmed; as the bottle of the gasometer 15 has a volume of 300 cm^3, one can measure gas up to the gas/oil ratio (GOR) of 5000 cubic feet per barrel.

The invention is not restricted to the illustrated embodiment, and various modifications in detail may be undertaken to the form of construction indicated without departing from the scope of the invention.

Hence in particular, instead of taking place by means of weighing, the volume of the auxiliary liquid [illegible] gasometer 15, can be measured by other means, for example by means of volumetric analysis.

CLAIMS

1. Automatic portable device for the thermodynamic analysis of a fluid, which is incorporated, together with the electronic monitoring and control devices which are connected to it, in several transport cases equipped with the necessary hydraulic and electronic linking components.

2. A device according to Claim 1, which comprises in combination a reservoir to contain a sample of a liquid containing a gas, to be analysed, a pressure reduction unit linked to the said reservoir and consisting of a cylinder comprising a transparent section making it possible to read, with the aid of an opto-electronic device, the level of the sample sucked into said cylinder by a movable piston moving progressively, the remainder of the liquid to be analysed being pulsed into the storage reservoir by a piston which is subject to the action of an auxiliary fluid contained in the lower section of a gasometer divided horizontally into two chambers by a flexible membrane above which accumulates, in the upper chamber, the gas given off by the sample when the bubble point thereof has been reached in the cylinder of the pressure reduction unit.

3. A device according to Claim 2, wherein a supply reservoir is provided from which the auxiliary fluid is sucked by a hand pump, making it possible, with the aid of a valve provided at the outlet, to adjust as necessary the level of the auxiliary liquid on the one hand in the gasometer linked to the pressure reduction unit and on the other hand in the reservoir also containing the sample to be analysed.

4. A device according to Claim 2 or 3, wherein an automatic-control throttle valve is provided, mounted on a pipe for evacuating the auxiliary fluid which leads to a reservoir resting on scales, which arrangement allows the determination of the weight of the auxiliary fluid forced from the chamber by the gas given off by the sample during pressure reduction which has entered the upper chamber of the gasometer.

5. A device according to Claim 2, 3 or 4, wherein the throttle valve regulating the volume of auxiliary fluid in the chamber of the gasometer is triggered by the signal provided by a pressure sensor which, linked by a pipe to the volume of liquid to be analysed contained in the pressure reduction cylinder, also allows control of the lifting mechanism of the piston travelling in the pressure reduction cylinder.

6. A device according to any of Claims 2 to 5, wherein the device monitoring the level [illegible]tronic system com-

parabolic mirror, the collimated beam of which, having traversed the transparent part of the cylinder at the level of the gas-oil interface in the pressure reduction chamber of the sample to be analysed, is sent onto a scale of photo-diodes, the number of points of which gives a number representing the height of the interface.

7. A device according to any of Claims 2 to 6, wherein the transparent part of the pressure reduction cylinder consists of a sapphire tube of suitable thickness which is wedged between an upper block of the cylinder and the lower block of the latter, the said blocks being held together by at least three braces securing a part shaped like an inverted bell, containing three washers transmitting their pressure to an intermediary sleeve holding the lower block in place with interposition of a further washer, the components of which are separated by a spherical contact surface, ensuring centering on the axis of the sapphire tube, in order to avoid any breakage during tightening.

8. A device according to any of Claims 2 to 7, wherein the base of the cylinder for reducing the pressure of the fluid to be analysed is sealed by a nut held in place by a threaded sleeve screwed into the lower block and on which are threaded on the one hand the double plug-washer and on the other the sleeve on which are threaded the three washers.

9. A device according to any of Claims 2 to 8, wherein the upper part of the piston travelling in the pressure reduction cylinder is linked, by a non-rigid coupling, to a screw moved vertically by a ball reducer transforming into a vertical motion the rotation of the driven shaft of a driving motor.

10. An automatic portable device for analysis of a fluid, substantially as hereinbefore described with reference to or as shown in Figs. 1 to 3 of the accompanying drawings.

11. A method of thermodynamic analysis of a fluid when a device as claimed in any preceding claim is used.

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